Wood, Joanne M. & Owsley, Cynthia (2005) How does vision drive driving performance? *Optometry and Vision Science*, *82*(8), pp. 639-640.

Guest editorial

The theme of this feature issue is the emerging research area of vision and driving. From the diverse nature of the papers included in this volume, it is clear that this topic has a much broader focus than that of developing vision standards for driver licensing, and includes among others, prediction of how visual impairment affects on-road driving performance, the role of visual attention and other visuocognitive factors in driver performance and safety, better understanding of the role of eye and head movements while driving, self regulation and driving cessation as assessed by self-report measures, night driving, vehicle design issues and the development and justification of vision standards for professional workers. Collectively these papers underscore the importance of this research area at both a theoretical level, facilitating a better understanding of the relationship between different aspects of a driver's vision on indices of driving performance, to the real world ramifications of improving road safety, emphasizing the need for high quality, well controlled studies which can provide this information.

In today's society, where driving is synonymous with the maintenance of independence, and where issues of equity and access can no longer be ignored, it is imperative that vision standards for licensure, or more importantly denial thereof, are based upon sound empirical evidence. Historically in this field, the role of vision in driving has been largely investigated by examining the relationship between measures of visual function and safety. Safety is usually defined in terms of adverse driving events such as crash involvement (e.g., at-fault crashes, injurious crashes) or moving violations (e.g., speeding, failure to obey traffic control devices). Measures of safety are often expressed statistically, such as a risk ratio or odds ratio where a subgroup of drivers of special interest is compared to a reference group (e.g., visually impaired drivers compared to drivers who have 20/20 visual acuity or better). There is a great deal of emphasis placed on safety in our society, and thus epidemiological studies have had as their goal the identification of visual factors that elevate the likelihood of crashing in a statistical sense. However, safety studies do not readily address the question of which visual capabilities and skills are related to actual driving performance itself, since the dependent measures in safety studies are adverse events and not elements of driver behavior and vehicle control.

An alternative research paradigm rapidly growing in popularity is the measurement of driver performance on the road and its relationship to visual capabilities. Performance is usually operationalized as accuracy or latency of a driving maneuver (e.g., staying in lane, braking to avoid a collision), exhibiting certain behaviors (e.g., using mirrors), and/or some aspect of driving quality according to some graded scale. Several papers in this special issue are illustrative of this approach. The papers by Bowers et al, Racette & Casson, Higgins & Wood, Vargas-Martin & Garcia-Perez and Falkmer demonstrate we are now seeing a shift toward study designs that are much better positioned to determine the role of vision in driving performance. These studies include the use of closed and open road assessments as direct measures of driving behavior, as well as driving simulators. Driver performance paradigms are more likely to better reflect the complex interplay of visual sensory and visuocognitive abilities and driving skills than are epidemiological studies where crash involvement is the primary outcome. A desirable outcome of such research is to provide an evidence basis for visual standards for driving.

Another growing trend is the study of factors affecting visual search including eye movements and head-eye coordination, which has obvious face validity in the driving task. It is now firmly established that effective control of a vehicle depends upon more than visual sensory factors such as contrast sensitivity, visual field sensitivity, and spatial resolution, but must also incorporate visuo-cognitive, oculomotor, and judgment/decision-making skills. Several studies in this issue illustrate this line of work including those papers by Summala, Clay, Horswill et al, and Chaparro et al.

The current demographic trend of an increasingly ageing society has significant ramifications for road safety. Crash statistics indicate that older drivers have unacceptably high crash rates and are more frequently cited as being 'at fault' in crashes. This has not been a major issue in the past as the elderly have tended to drive fewer miles than their younger counterparts, and have not been over-represented in the absolute number of crashes incurred. However, the current generation of older drivers often consider driving to be a right rather than a privilege and wish to maintain their mobility and independence. The current older driver cohort is also driving more annual miles than previous cohorts resulting in more older drivers, many of whom will have visual impairment. This will result in increased numbers of fatalities unless appropriate precautions are introduced. Importantly, however, many older drivers limit their driving exposure and this decision appears to be related to impaired performance on multiple measures of vision, as discussed by Freeman et al. The problems of the older driver are also exacerbated under night-time driving situations, in part due to decrements in visual performance, arising from reduced contrast sensitivity. As a result, many older drivers limit their night driving, and as discussed by Brabyn et al. this is again related to their visual characteristics. However, there are many older drivers who wish to drive at night, and their numbers are likely to increase in the future, which will change current driving patterns and increase the amount of night driving undertaken by the elderly. Such a trend is particularly important in the context of the considerable evidence indicating that most serious road accidents happen at night.

Identifying the visual factors important to safe night-time driving is another important issue given that night-time fatality rates, adjusted for mileage, are 3-4 times higher than daytime rates and is explored in this Feature issue in papers by Planis, Brooks et al, and Wood & Owens. These researchers have used experimental designs incorporating laboratory–based measures, simulator and closed road assessments to demonstrate that drivers' ability to see real world objects at night-time is seriously degraded, that drivers tend to be unaware of this degradation because their steering ability remains unaffected and that these night-time decrements are better predicted by tests of contrast sensitivity than by visual acuity.

As eye care professionals, optometrists and ophthalmologists are often asked to comment on visual standards for different occupations and are requested to assess patients against these standards. These decisions often are critical to the quality of life of the patient given that they may loose their job and potential livelihood dependent upon the outcome. Like the vision testing for vehicle licensing, these standards commonly have a historical context rather than being evidence-based. Both Johnson and Schwartz have tackled this question for two very different occupations, providing useful models of how the visual measures required for a given occupation can be derived from sound empirical evidence,

defining the visual requirements of a particular occupation to provide appropriate evidence-based standards, against which potential candidates can be tested. .

In summary, there are many critical and as yet unanswered questions regarding the visual requirements for safe driving. Alternative research strategies, including the assessment of actual driving performance as described in studies included in this feature issue, are needed to complement epidemiological studies focused on safety issues, which together can provide us with a greater understanding of the vision and driving. Vision scientists have a significant role to play in this regard and should be actively involved in ongoing research and debate. This issue is also relevant to the wider vision community, as many patients will consult with their optometrist or ophthalmologist as to whether their vision is sufficient for safe driving. However, in the absence of an evidence-basis for these recommendations, it can be difficult to offer such patients accurate advice. This further underscores the need to better develop this important research area to gain better insights into the relationship between vision and driving. The papers contained in this feature issue provide some excellent examples of the directions researchers are taking to develop this knowledge base.